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Use of a Self-leveling Laser Indicator for Determination of Proper Hook Position with Respect to the Load of a Crane.

J. Segal

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Abstract

A novel application of a laser indicator to the proper positioning of the hook with respect to the load for the overhead gantry crane in Hall A.

1. Introduction

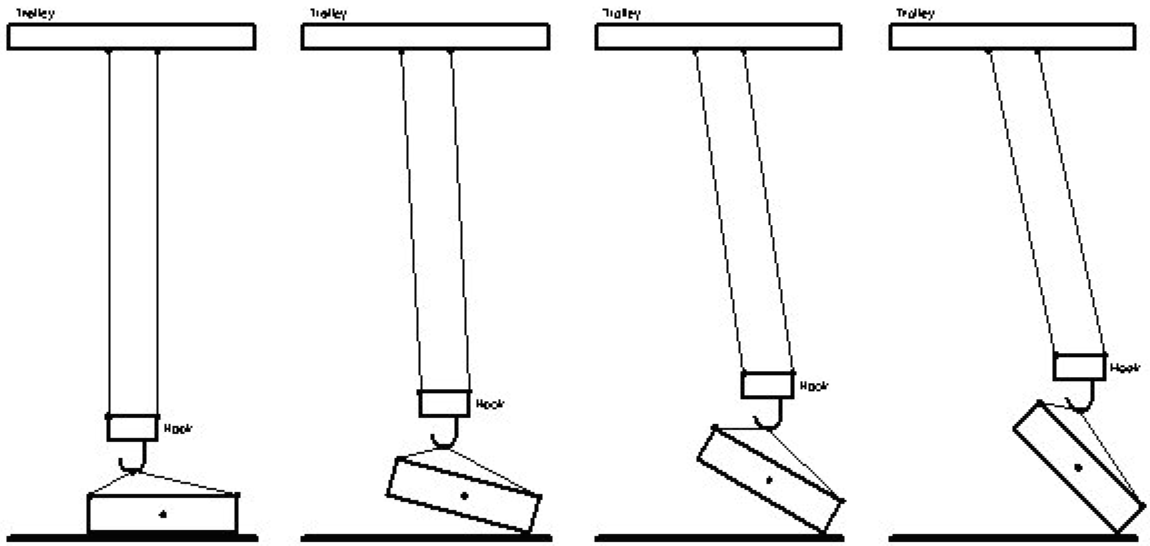
   Lifting with the overhead crane in Hall A frequently requires picking up loads which have an unknown center of gravity or need to be picked up at angles to the horizontal.

   The standard method of stepping back and visually inspecting the vertical alignment of the rigging gear, hook, wire rope, and the trolley is often insufficient to prevent the load from either sliding on the ground while beginning the lift or swinging unacceptably when it loses contact with the surface it is resting on. This is caused by the hook being out of vertical alignment with the trolley.

   A novel use of a self-leveling laser indicator is presented to aid in the proper vertical alignment of the hook, wire rope, and the trolley. The method presented has broader application to various lifting devices. Several possible arrangements and one tested method will be discussed.

2. Development of a sideways pull

   In order to achieve a straight, smooth lift of a load in Hall A it is necessary that the trolley, wire rope, hook and the center of gravity of the load all be lined up vertically. When this is not the case a sideways component of pull is applied to the load. This sideways pull can cause the load to slide if the pull exceeds the static friction of the portion of the load in contact with the supporting surface. If the load does not slide, when it is lifted off the surface it will begin to swing. How far the load swings is a funtion of how much sideways pull is on the load, the weight of the load and how much wire rope is played out. The figure below shows how a sideways pull develops if the trolley and bridge are not moved while picking a load.



In this side view of the setup the required motion of the trolley is fairly easy to discern. However, in a front or rear view of the setup (along the plane of this paper rather than perpendicular to the plane of the paper), estimating how much to move the trolley becomes almost guesswork.

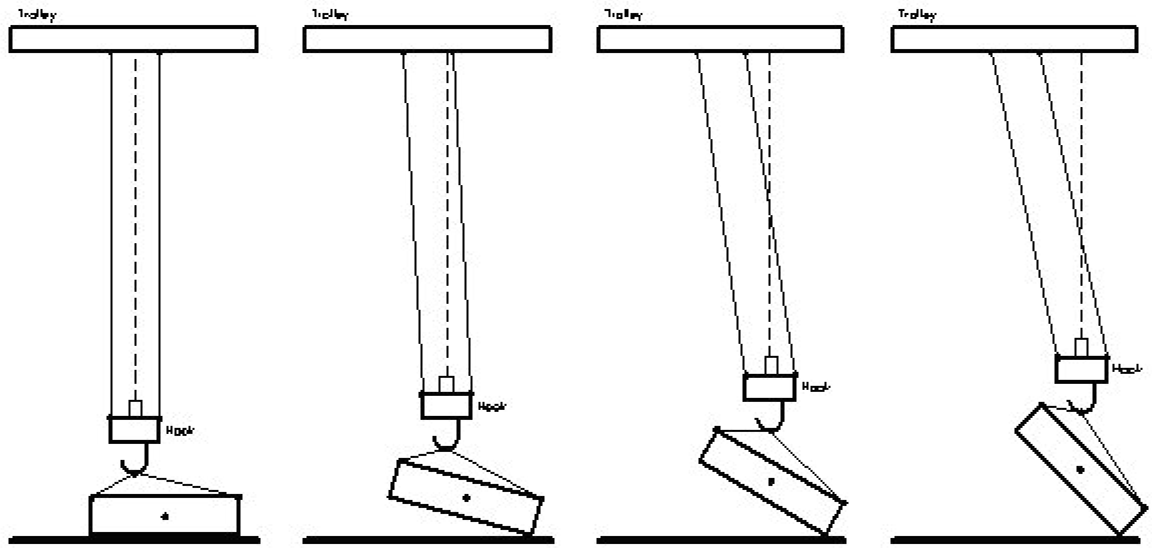
Presently the recourse in a similar situation has been to position either the crane operator or a signaler where they can have such a side view. There are situations where this is impossible or impractical, leaving the crane operator to their best guess as to the positioning of the trolley.

3. A self-leveling laser indicator to aid in alignment

   Mounting a fixed vertically pointing laser on the hook block might seem reasonable at first, but the long lever arm made by the distance from the trolley to the hook block is a problem. Any tilt of the hook block will translate into a much larger shift in position of the laser spot on the trolley.

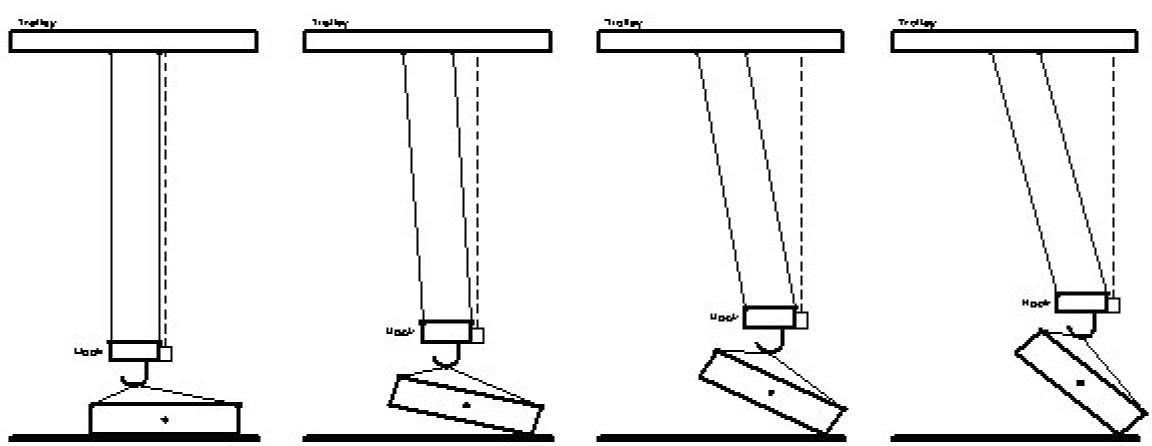
   A self-leveling laser mounted on the hook block will eliminate the errors arising from the hook block-to-trolley lever arm. Leaving only the smaller errors due to the lever arms from the laser to the hook block components. A significant improvement in accuracy.

The laser spot on the trolley, or on a viewing screen mounted on the trolley, provides a less ambiguous feedback about the positioning of the hook with respect to the trolley. The figure below gives a basic idea of the function of the laser.



The crane operator or signaler may then watch the position of the laser spot on the trolley to garner additional information about positioning. Moving the trolley to maintain the laser spot on a specific place on the trolley will ensure the trolley and hook positioning are correct.

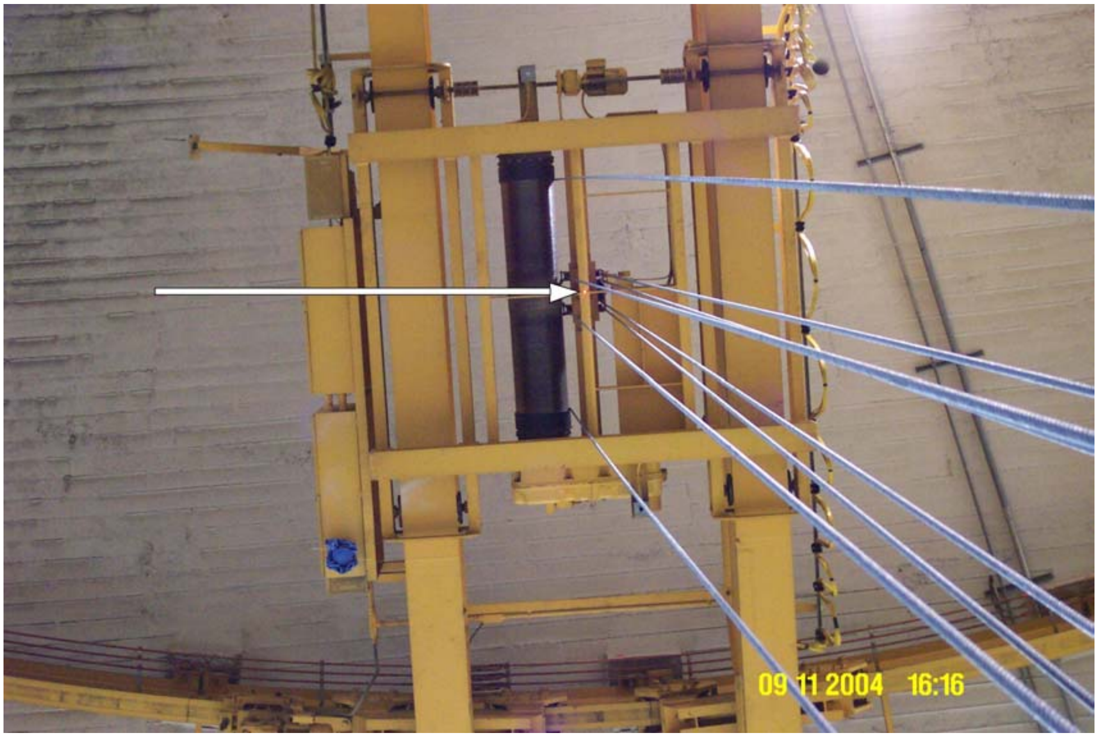
The following figure is merely to show that the laser need not be centered on the hook block, but may be attached where convenient. Possible loss in accuracy will be discussed later.



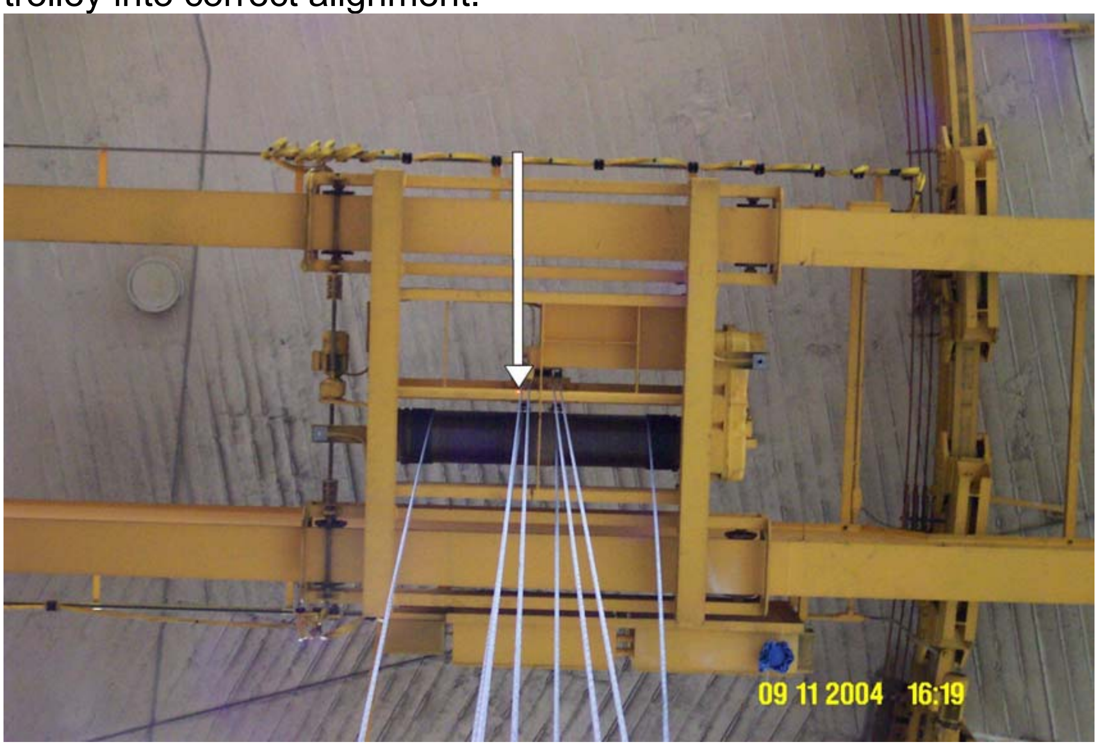
4. Practical implementation

   An inexpensive implementation of the laser indicator was achieved with the use of a DeWALT laser plumb indicator. Although the eddy current damping used in the DeWALT indicator is not optimal, the plumb has proved useful through nine months of occasional use. A pancake magnet was screwed to the base of the DeWALT plumb and used to secure the plumb to the top of the hook block of the Hall A crane. In the following photo an additional magnetic base was used to make positioning of the plumb easier. The additional base was eventually found to not be required for sufficiently accurate placement of the plumb.

   In the following photo the laser spot, located at the end of the white arrow, can be seen at the center of the trolley.



In the following photo the laser spot, located at the end of the white arrow, on the trolley indicates the hook block is not directly under the trolley for this lift. The trolley needs to be moved a short distance in order to bring the hook block and trolley into correct alignment.



5. Erratic motions of the laser

   The laser mounting must have sufficient damping in order to minimize erratic motions of the self-leveling laser arising from motions of the hook block. Although not all motion can be suppressed, it must be minimized. Ideally all of the motion of the spot on the trolley will be due to motions of the hook block and not due to oscillations of the self-leveling laser mounting. The oscillations of the self-leveling laser mounting being driven by the motions of the hook block. Eddy current damping is the most robust method. Viscous damping can also be employed, but complicates the entire mounting of the laser. Motions of the hook block which are periodic can be dealt with by taking the midpoint of the extremes of motion of the laser spot on the trolley.

6. Errors of the laser spot position on the trolley

   While this device eliminates the long hook block-to-trolley lever arm, it does not eliminate all sources of error. Any tilt of the hook block will translate into an error. The magnitude of the error depends on the specific mounting of the laser on the hook block.

   In Hall A the hook block is 17 inches long, has 10.5 inch diameter sheaves and 6 inches from the center of the sheaves to the top surface of the hook block. The hook block can easily have a 2 inch tilt over the 17 inch length with no load. If the reference laser spot on the trolley is determined with the hook block in this position there will be an error if the hook block becomes level when a load is being picked up. If the laser pivots at a point 4 inches above the block the error in the spot position on the trolley will be between (10* (2/17))=1.2 inches and 1.2+(17-16.88)=1.32 inches, depending upon where along the top of the block the laser is mounted. The sine of the angle of tilt being 2 inches divided by 17 inches. If the load loses contact with the surface while the hook and trolley are 1.32 inches out of alignment the arrangement essentially becomes a pendulum which has been pulled 1.32 inches to one side. The load would swing 2.64 inches before beginning to return. With careful use of the laser there would thus be no more than 3 inches of swing, in the worst case.

For a mounting on the side of a hook block similar geometric considerations will give the error in laser spot position on the trolley.

7. Admonishment

This device is a useful aid to the trained, attentive operator. It is not intended as a fail safe device.